

D4276, Revision 2 | Adding Fused Transform Algorithms to the Parallelism TS

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Summary

This document describes how to add the fused transform algorithms proposed by N4167 and various national body comments to N4105, the C++ Parallelism TS. The semantics of the algorithms described herein were taken from NVIDIA's Thrust algorithms library, described in N3408, and are common to other existing C++ algorithms libraries.

Additions to the Table of Algorithms

Add `transform_reduce`, `transform_exclusive_scan`, and `transform_inclusive_scan` to Table 1 of N4105.

Additions to `<experimental/numeric>` Synopsis

Add the following signatures to the namespace `std::experimental::parallel::v1` in S 4.4.1 [`parallel.alg.numeric.synopsis`] to N4105:

```
template<class InputIterator, class UnaryOperation, class T, class BinaryOperation>
    T transform_reduce(InputIterator first, InputIterator last,
                      UnaryOperation unary_op,
                      T init, BinaryOperation binary_op);
template<class ExecutionPolicy,
         class InputIterator, class UnaryOperation, class T, class BinaryOperation>
    T transform_reduce(ExecutionPolicy&& exec, InputIterator first,
                      InputIterator last,
                      UnaryOperation unary_op,
                      T init, BinaryOperation binary_op);

template<class InputIterator, class OutputIterator,
         class UnaryOperation, class T, class BinaryOperation>
    OutputIterator
    transform_exclusive_scan(InputIterator first, InputIterator last,
                            OutputIterator result,
                            UnaryOperation unary_op,
                            T init, BinaryOperation binary_op);
template<class ExecutionPolicy,
         class InputIterator, class OutputIterator,
         class UnaryOperation, class T, class BinaryOperation>
```

```

OutputIterator
    transform_exclusive_scan(ExecutionPolicy&& exec, InputIterator first, InputIterator last,
                            OutputIterator result,
                            UnaryOperation unary_op,
                            T init, BinaryOperation binary_op);

template<class InputIterator, class OutputIterator,
        class UnaryOperation, class BinaryOperation>
OutputIterator
    transform_inclusive_scan(InputIterator first, InputIterator last,
                             OutputIterator result,
                             UnaryOperation unary_op,
                             BinaryOperation binary_op);

template<class InputIterator, class OutputIterator,
        class UnaryOperation, class BinaryOperation, class T>
OutputIterator
    transform_inclusive_scan(InputIterator first, InputIterator last,
                             OutputIterator result,
                             UnaryOperation unary_op,
                             BinaryOperation binary_op, T init);

template<class ExecutionPolicy,
        class InputIterator, class OutputIterator,
        class UnaryOperation, class BinaryOperation>
OutputIterator
    transform_inclusive_scan(ExecutionPolicy&& exec, InputIterator first, InputIterator last,
                             OutputIterator result,
                             UnaryOperation unary_op,
                             BinaryOperation binary_op);

template<class ExecutionPolicy,
        class InputIterator, class OutputIterator,
        class UnaryOperation, class BinaryOperation, class T>
OutputIterator
    transform_inclusive_scan(ExecutionPolicy&& exec, InputIterator first, InputIterator last,
                             OutputIterator result,
                             UnaryOperation unary_op,
                             BinaryOperation binary_op, T init);

```

Add S 4.4.5 Transform reduce [parallel.alg.transform.reduce] to N4105:

```

template<class InputIterator, class UnaryFunction, class T, class BinaryOperation>
T transform_reduce(InputIterator first, InputIterator last,
                  UnaryOperation unary_op, T init, BinaryOperation binary_op);

```

Returns: *GENERALIZED_SUM*(binary_op, init, unary_op(*first), ..., unary_op(*(first + (last - first) - 1))).

Requires: Neither unary_op nor binary_op shall invalidate subranges, or modify elements in the range [first,last).

Complexity: $O(\text{last} - \text{first})$ applications each of unary_op and binary_op.

Notes: transform_reduce does not apply unary_op to init.

Add S 4.4.6 Transform exclusive scan [parallel.alg.transform.exclusive.scan] to N4105:

```
template<class InputIterator, class OutputIterator,
         class UnaryOperation,
         class T,
         class BinaryOperation>
OutputIterator
transform_exclusive_scan(InputIterator first, InputIterator last,
                        OutputIterator result,
                        UnaryOperation unary_op,
                        T init, BinaryOperation binary_op);
```

Effects: Assigns through each iterator *i* in $[result, result + (last - first))$ the value of *GENERALIZED_NONCOMMUTATIVE_SUM*(*binary_op*, *init*, *unary_op*(**first*), ..., *unary_op*(*(*first* + (*i* - *result*) - 1))).

Returns: The end of the resulting range beginning at *result*.

Requires: Neither *unary_op* nor *binary_op* shall invalidate iterators or subranges, or modify elements in the ranges $[first, last)$ or $[result, result + (last - first))$.

Complexity: $O(last - first)$ applications each of *unary_op* and *binary_op*.

Notes: The difference between *transform_exclusive_scan* and *transform_inclusive_scan* is that *transform_exclusive_scan* excludes the *i*th input element from the *i*th sum. If *binary_op* is not mathematically associative, the behavior of *transform_exclusive_scan* may be non-deterministic. *transform_exclusive_scan* does not apply *unary_op* to *init*.

Add S 4.4.7 Transform inclusive scan [parallel.alg.transform.inclusive.scan] to N4105:

```
template<class InputIterator, class OutputIterator,
         class UnaryOperation,
         class BinaryOperation>
OutputIterator
transform_inclusive_scan(InputIterator first, InputIterator last,
                        OutputIterator result,
                        UnaryOperation unary_op,
                        BinaryOperation binary_op);
```

```
template<class InputIterator, class OutputIterator,
         class UnaryOperation,
         class BinaryOperation, class T>
OutputIterator
transform_inclusive_scan(InputIterator first, InputIterator last,
                        OutputIterator result,
                        UnaryOperation unary_op,
                        BinaryOperation binary_op, T init);
```

Effects: Assigns through each iterator *i* in $[result, result + (last - first))$ the value of *GENERALIZED_NONCOMMUTATIVE_SUM*(*binary_op*, *unary_op*(**first*), ..., *unary_op*(*(*first* + (*i* - *result*))) or *GENERALIZED_NONCOMMUTATIVE_SUM*(*binary_op*, *init*, *unary_op*(**first*), ..., *unary_op*(*(*first* + (*i* - *result*))) if *init* is provided.

Returns: The end of the resulting range beginning at `result`.

Requires: Neither `unary_op` nor `binary_op` shall invalidate iterators or subranges, or modify elements in the ranges `[first,last)` or `[result,result + (last - first))`.

Complexity: $O(\text{last} - \text{first})$ applications each of `unary_op` and `binary_op`.

Notes: The difference between `transform_exclusive_scan` and `transform_inclusive_scan` is that `transform_inclusive_scan` includes the *i*th input element from the *i*th sum. If `binary_op` is not mathematically associative, the behavior of `transform_inclusive_scan` may be non-deterministic. `transform_inclusive_scan` does not apply `unary_op` to `init`.